DOCUMENT RESUME

ED 114 199 PS 008 163

AUTHOR	Ausman, Lynn M.
TITLE	Nutritional Findings and Early Behavioral Observations.
PUB DATE	Apr 75
NOTE	14p; For related documents, see PS 008 164-166; Paper presented at the Biennial Meeting of the Society for Research in Child Development (Denver, Colorado, April 10-13, 1975)
EDRS PRICE	MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS	*Animal Behavior; Body Weight; *Dietetics; Motor Development; *Nutrition; *Physical Development
IDENTIFIERS	*Protein Deficiency; Squirrel Monkeys

ABSTRACT

This study investigated the effects of a short period of severe protein malnutrition on subsequent growth and development in the squirrel monkey. A total of 12 newborn monkeys were fed a low protein die from 2 to 8 weeks of age then rehabilitated by returning them to the 13 percent protein diet of the control group. Minimum amount of protein needed for maximum growth was about half that of the control diet. For one year, measures of body weight, plasma protein and albumin concentration, hemoglobin and locomotion were collected for protein deficient and control animals. Results, which show lasting effects of body weight deficit and markedly depressed plasma albumin levels during the malnutrition, attest to the severity of protein malnutrition induced in these animals. Autopsy data indicate that brain weights were depressed and that malnutrition interfered with brain development. (GO)

Documents acquired by ERIC include many informal unpublished materials not available from other sources. ERIC makes every effort to obtain the best copy available. Nevertheless, items of marginal reproducibility are often encountered and this affects the quality of the microfiche and hardcopy reproductions ERIC makes available via the ERIC Document Reproduction Service (EDRS). EDRS is not responsible for the quality of the original document. Reproductions supplied by EDRS are the best that can be made from the original.

ED114199

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

NUTRITIONAL FINDINGS AND EARLY BEHAVIORAL OBSERVATIONS

Lynne M. Ausman

Monkeys used in this study were removed from their mothers on the day of birth and hand-reared in the monkey nursery using liquid formulae designed and prepared by us. These diets were a mixture of semi-purified ingredients with casein as the protein source and with minerals and vitamins added in sufficient amounts for adequate growth. One-half the animals, considered as controls, were fed 13% of the dietary calories as protein throughout the year experiment. The twelve animals receiving the low protein diet from 2 through 8 weeks of life were fed diets varying from 2.0 to 5.0% of the calories as protein as demanded by each individual monkey for weight maintenance. At eight weeks of age, protein deficient animals were rehabilitated by returning them to the control diet for the reaminder of the year. These levels of protein were chosen on the basis of results of experiments which investigated the protein requirements of these monkeys. SLIDE 1. If young growing squirrel monkeys are fed diets containing graded levels of dietary protein, one may plot their response in body weight during a given time period relative to their protein intake (g/kg/day). Straight line regressions have been fitted to each linear portion of the curve. The intersection of the regression line with zero weight change supplies an estimate of the protein requirement for weight maintenance of the infant squirrel monkey. This is approximately 4 grams casein/kg/day. The point of intersection of the two regression lines with each other provides an estimate of the minimum amount of protein needed for maximum weight gain and this was about 6.5-7.0 g/kg/day. Considering the caloric intake of these animals, these levels translate to diets containing about 4 and 7% dietary protein, respectively. Our control diet is 13% protein or about double that demonstrated to be necessary for maximum growth.

PS 008163

Of 23 animals beginning the study, 4 deaths occurred in the protein deficient group. Deaths at 17 and 25 weeks of age were due to a liver abscess and kidney failure, respectively. A death at 8 weeks was attributed to general malnutrition and that at 42 weeks to accidental strangulation with the neck tag.

Rearing conditions did not produce a detectable effect on the biochemical and hematologic development of either the control or protein deficient monkeys. Therefore, data presented on hemoglobin, plasma protein and albumin concentrations and body weight are presented without regard to rearing condition.

SLIDE 2 depicts the body weight of the male animals used in the study. The solid line represents the body weight of the 3 control males and the broken line the body weight of the protein deficient males. Thirteen additional control males in a contemporaneous experiment were added to the growth curve of the 3 control males to make an enlarged growth standard $\pm$ 2 s.d. shown as the gray area. Introduction of the protein deficient diet stopped weight gain of these animals for the six week period. Using either control growth standard, the mean body weight of the protein deficient animals was significantly reduced at 18 but not at 42 and 52 weeks of age. Psychological tests were carried out at these times. Calculation of z scores for each individual monkey indicated that only one out of 5 had a body weight within 2 standard deviations of the normal mean at 18 weeks, 3 out of 4 at 42 weeks and 2 out of 4 at 52 weeks.

SLIDE 3 is a graph of the body weights of the female monkeys in the study. The solid line represents the body weight of the 8 control female monkeys and the broken line the 6 protein deficient female monkeys. Again, 4 control animals from a simultaneous study were included to make an enlarged growth standard $\pm$ 2 s.d. The low protein diet virtually stopped growth of the protein deficient monkeys between 2 and 8 weeks of age. However, individual monkeys increased their body weight after rehabilitation at different rates. The mean body weight of the protein deficient group was significantly reduced only at 18 but not at 42 and 52

weeks, respectively. The fact that male monkeys had not fully recovered their expected body weight by one year but females had may be due to the greater growth expected of the male monkey

SLIDE 4 is a graph of plasma protein and plasma albumin concentrations for control and deficient monkeys. As no sex differences were observed, data were pooled for sexes. Total plasma protein concentrations were significantly reduced (as indicated by the stars) in the deficient group at 4 and 6 weeks of age. Plasma albumin concentrations were significantly reduced at 4, 6, 8, and 10 weeks of age. They appeared to be the more sensitive indicator of malnutrition. This result is generally also found in malnourished human beings. A measure ot total protein concentration includes fractions such as gamma-globulin which often increase with infection or malnutrition. Within 4 weeks after rehabilitation, all monkeys showed normal plasma albumin and total plasma protein concentrations indicating a rapid recovery of these biochemical parameters.

SLIDE 5 graphs hemoglobin concentrations of the monkeys through the year study. Hemoglobin concentrations were significantly reduced only at 8 weeks of age ($p < 0.05$). For purposes of comparison, values for the 2 animals with the liver abscess and kidney failure were ommitted as it is generally known that infection and uremia produce a severe inhibition of the bone marrow and a subsequent anemia. A significant difference was also seen at 24 weeks of age but this was attributed to two aberrantly high values in the control group.

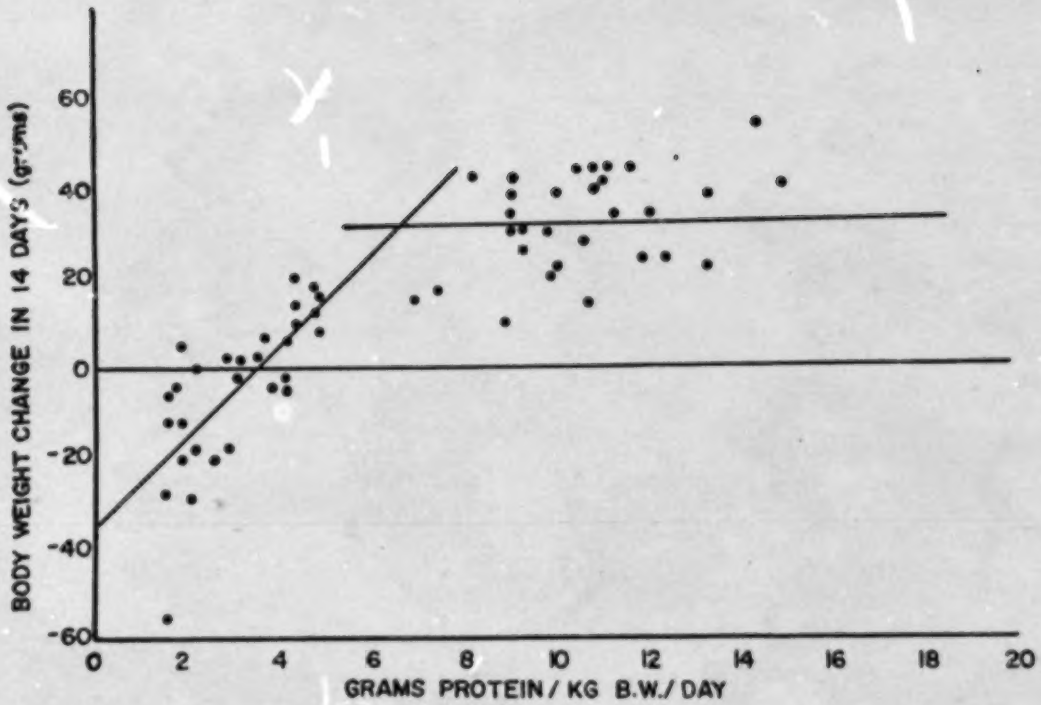
Hematologic indicies were not important indicators of malnutrition in this study, perhaps because a high quality protein, casein, was used. However, in experiments using protein sources of poorer quality such as soybean, a severe anemia often does develop.

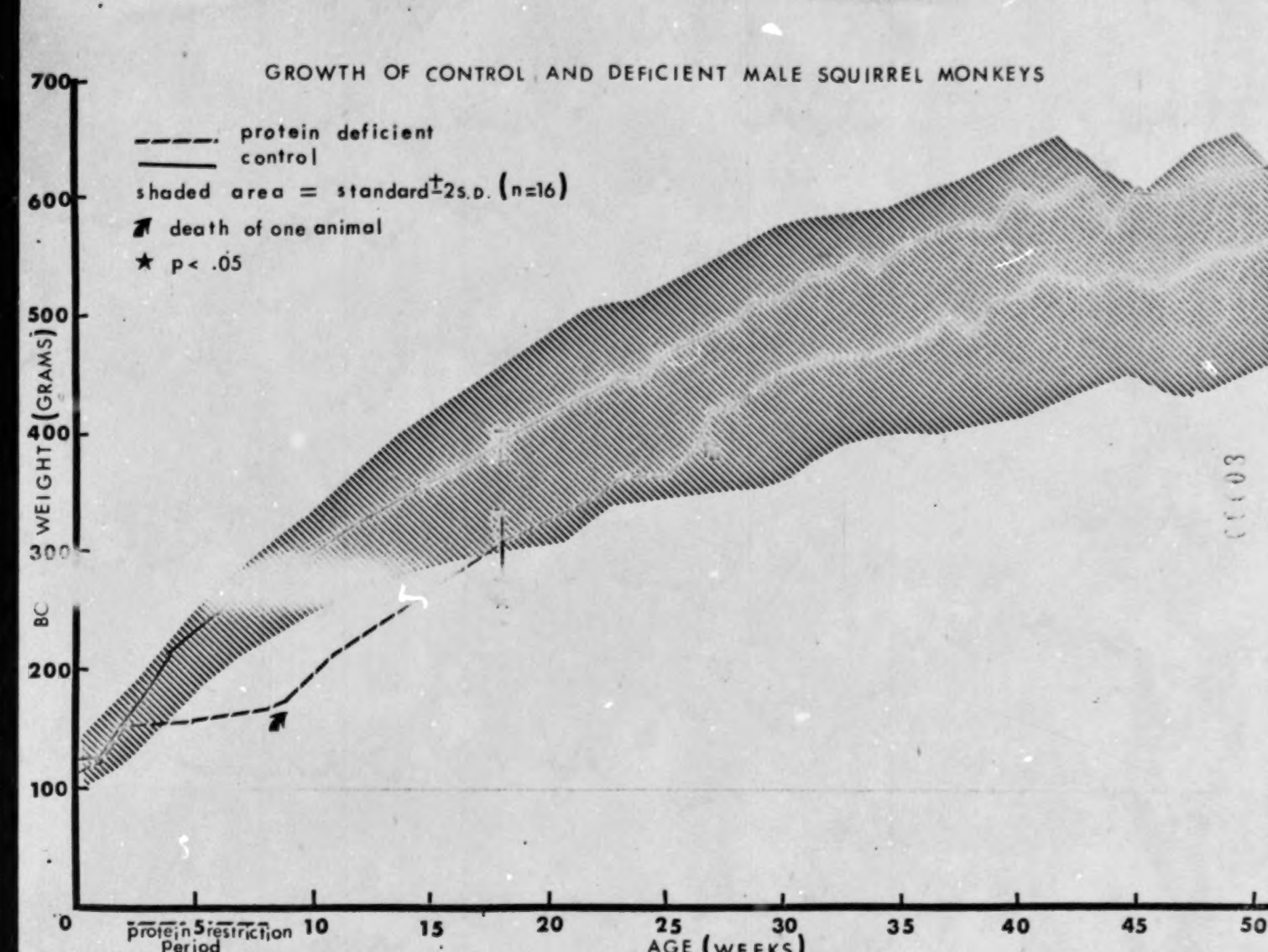
Several observations of activity were made during and immudiately following the period of protein deprivation. One measure of activity, locomotion, was

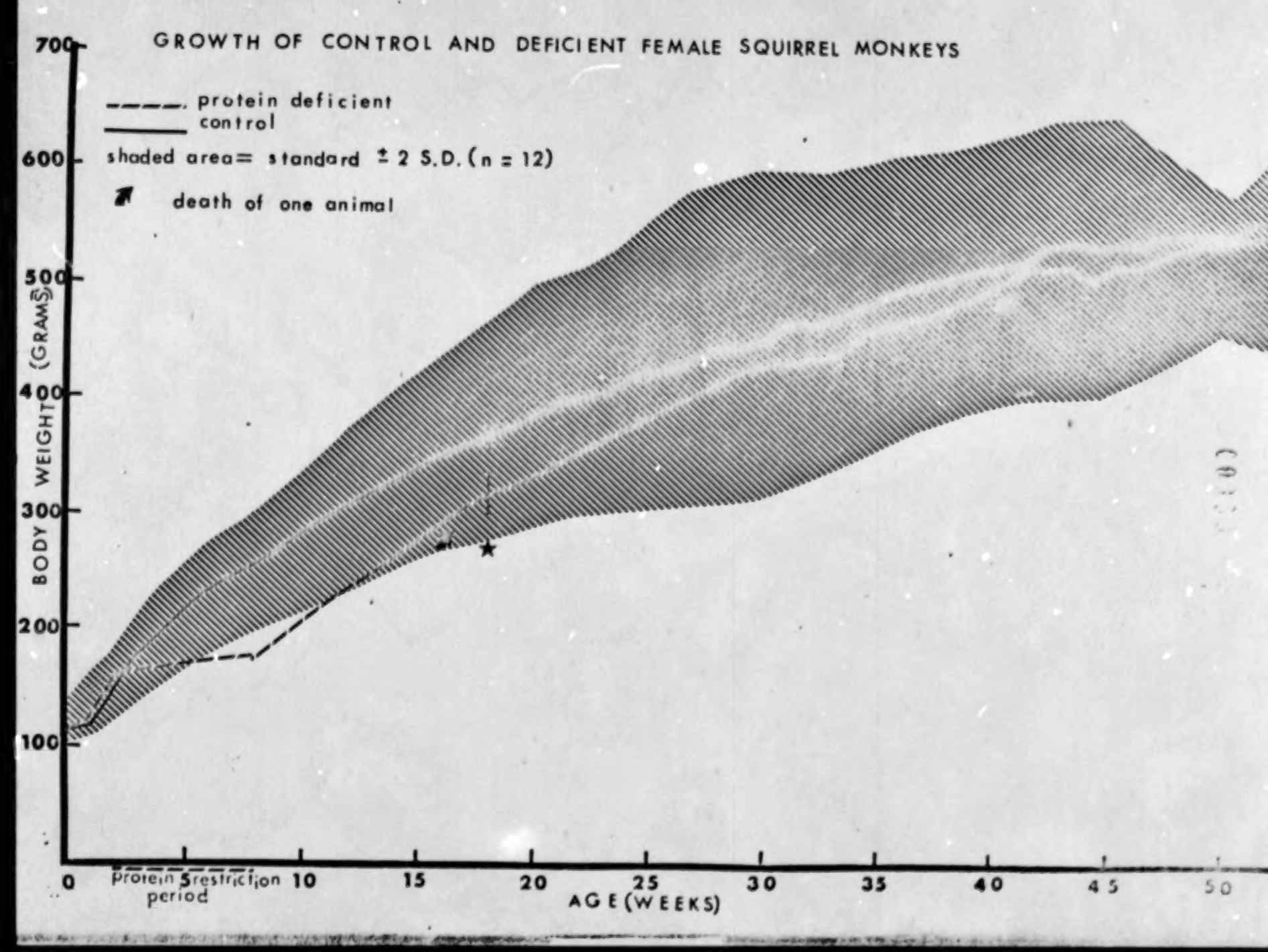
derived from data collected during observations of social behavior which will be reported more fully later. Locomotion of any kind was scored if an animal moved one-half a body length during each 15 second epoch for 10 minutes whether the animal moved only the criterion distance or continued to move throughout the 15 seconds. This category has a low ceiling of 40 observations but provides a gross measure of activity. SLIDE 6 shows changes in locomotion with both age and diet. The change in age was significant as both groups of animals showed increased locomotion until 16 weeks of age. No further increase was found at 20 weeks. Difference according to dietary conditions alone were not statistically significant except at 8 weeks ($F=33.4$, $df=1/24$, $p=.001$) when protein deficient animals were severely malnourished. By 12 weeks of age when plasma protein and albumin concentrations had reached normal concentrations in the deficient group, no statistical difference in locomotion was seen between the control and protein deficient groups. SLIDE 7 shows that rearing conditions accounted for group differences ($F=33.4$, $df=1/24$, $p=.001$) with the handled group more active at every point measured than the nonhandled group. SLIDE 8 shows subgroup differences which were not significant across weeks ($p=0.055$). This graph shows the differences handling accounts for in the two protein deficient groups with the nonhandled deficient group less active at every point measured than the handled deficient group.

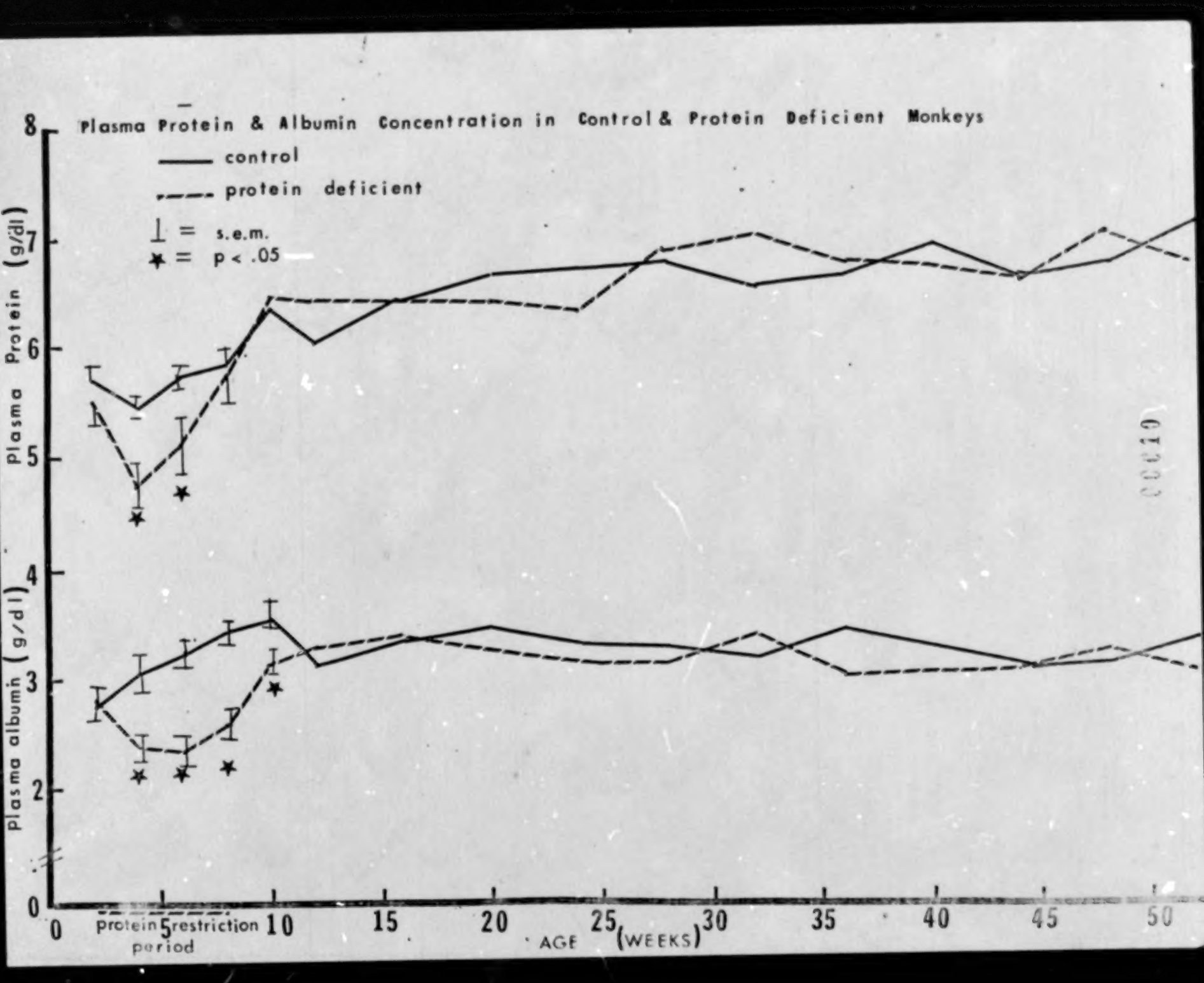
The lasting effects of the body weight deficit in some monkeys as well as markedly depressed plasma albumin levels during the malnutrition attest to the severity of the protein malnutrition induced in these animals. Indeed, in our hands, imposed weight maintenance of a 2 week old squirrel monkey (due to protein restriction) may not be continued for periods much longer than we have used if a significant proportion of the animals are to survive. The severity of the

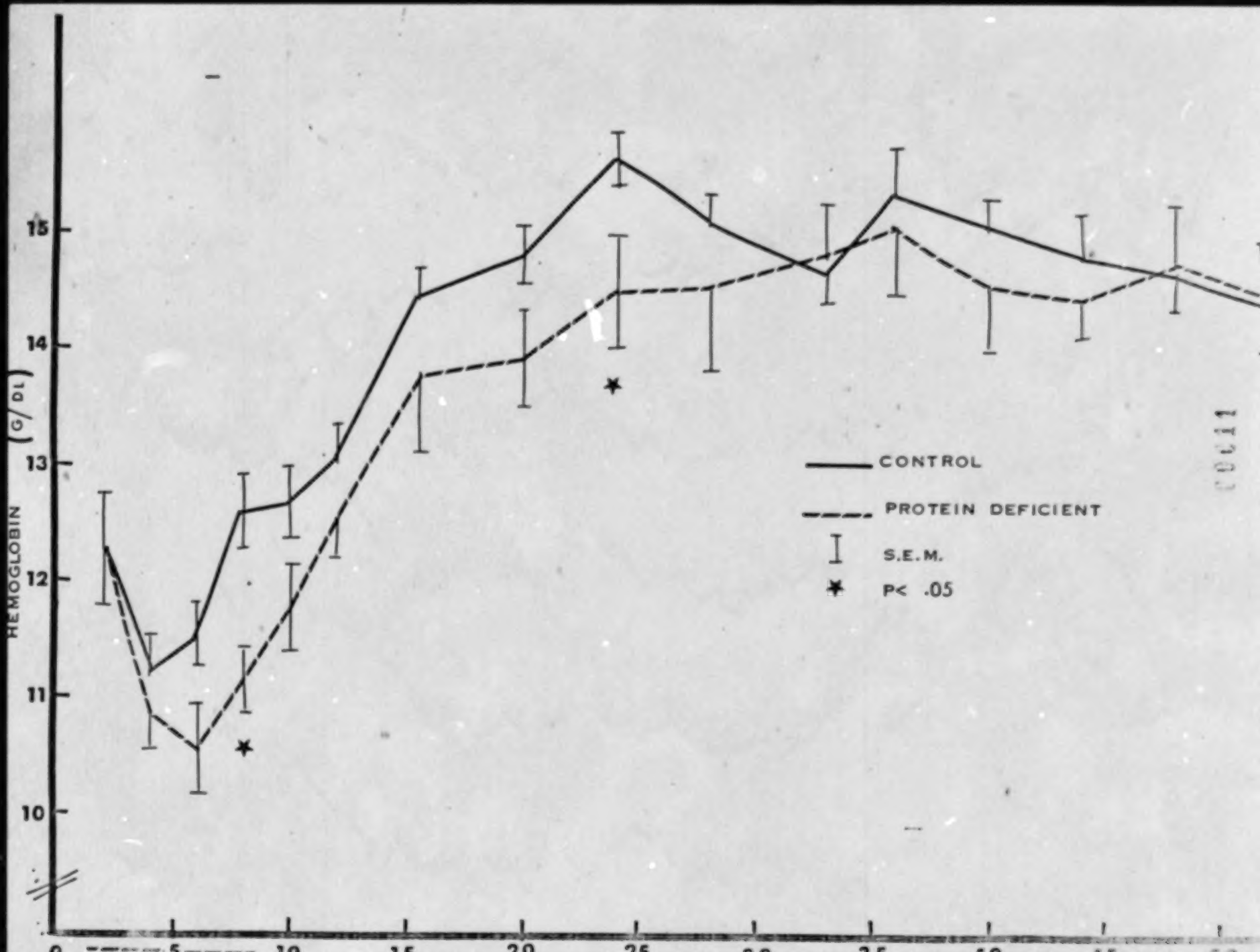
malnutrition was also reflected in reduced locomotion at 8 weeks in the deficient group. Autopsy data of a limited number of animals killed or dying of malnutrition in the period of 2 through 8 weeks indicates that brain weights were depressed below the norm for age and that malnutrition interferred with brain development.


BODY WEIGHT CHANGE IN 14 DAYS (grams)
60
40
20
0
-20
-40
-60
0
2
4
6
8
10
12
14
16
18
20
GRAMS PROTEIN / KG B.W./ DAY

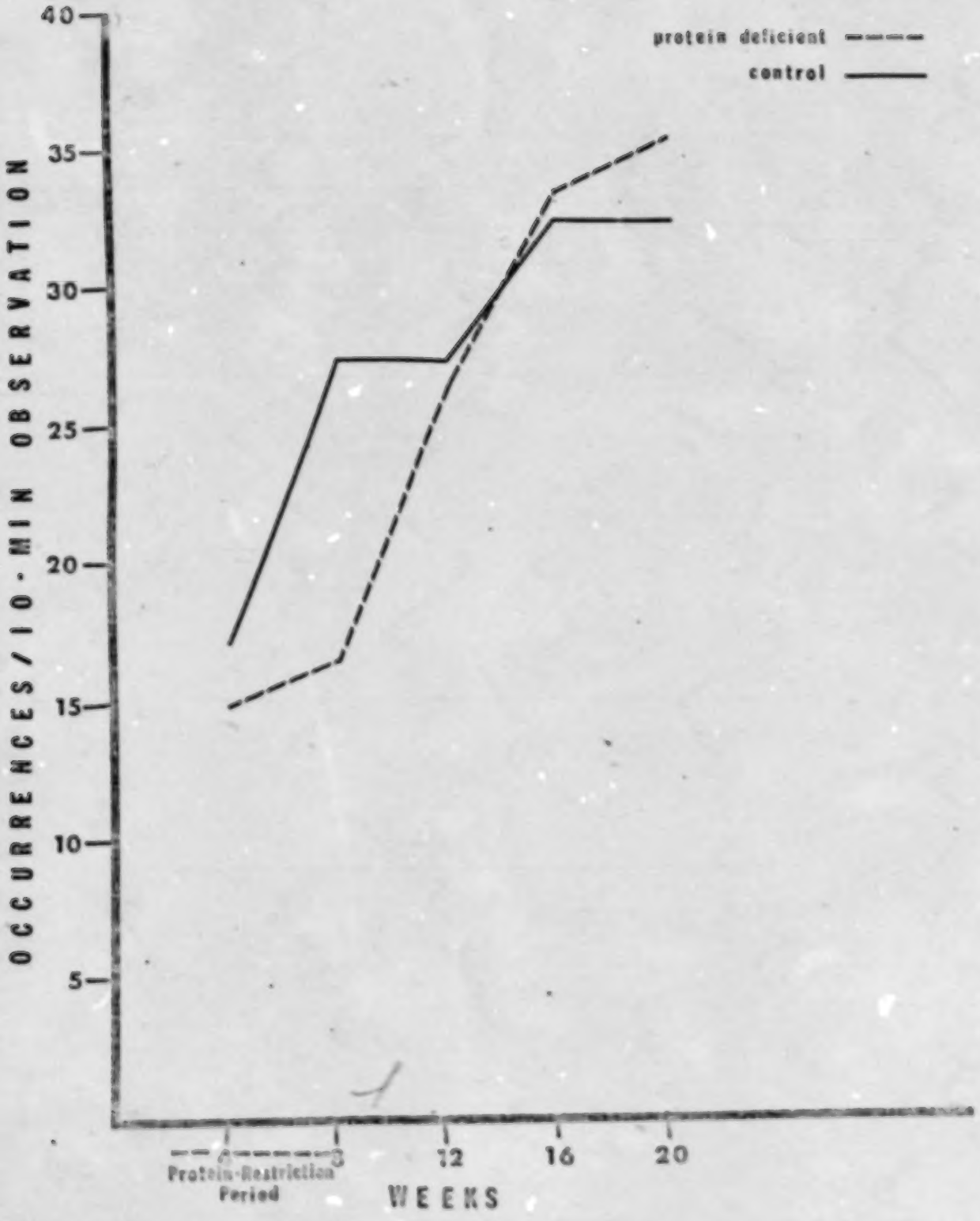

GROWTH OF CONTROL AND DEFICIENT MALE SQUIRREL MONKEYS
protein deficient
control
shaded area = standard ±2s.d. (n=16)
death of one animal
★ p< .05
WEIGHT (GRAMS)
700
600
500
400
300
200
100
BC
0
protein restriction Period
5
10
15
20
25
30
35
40
45
50
AGE (WEEKS)

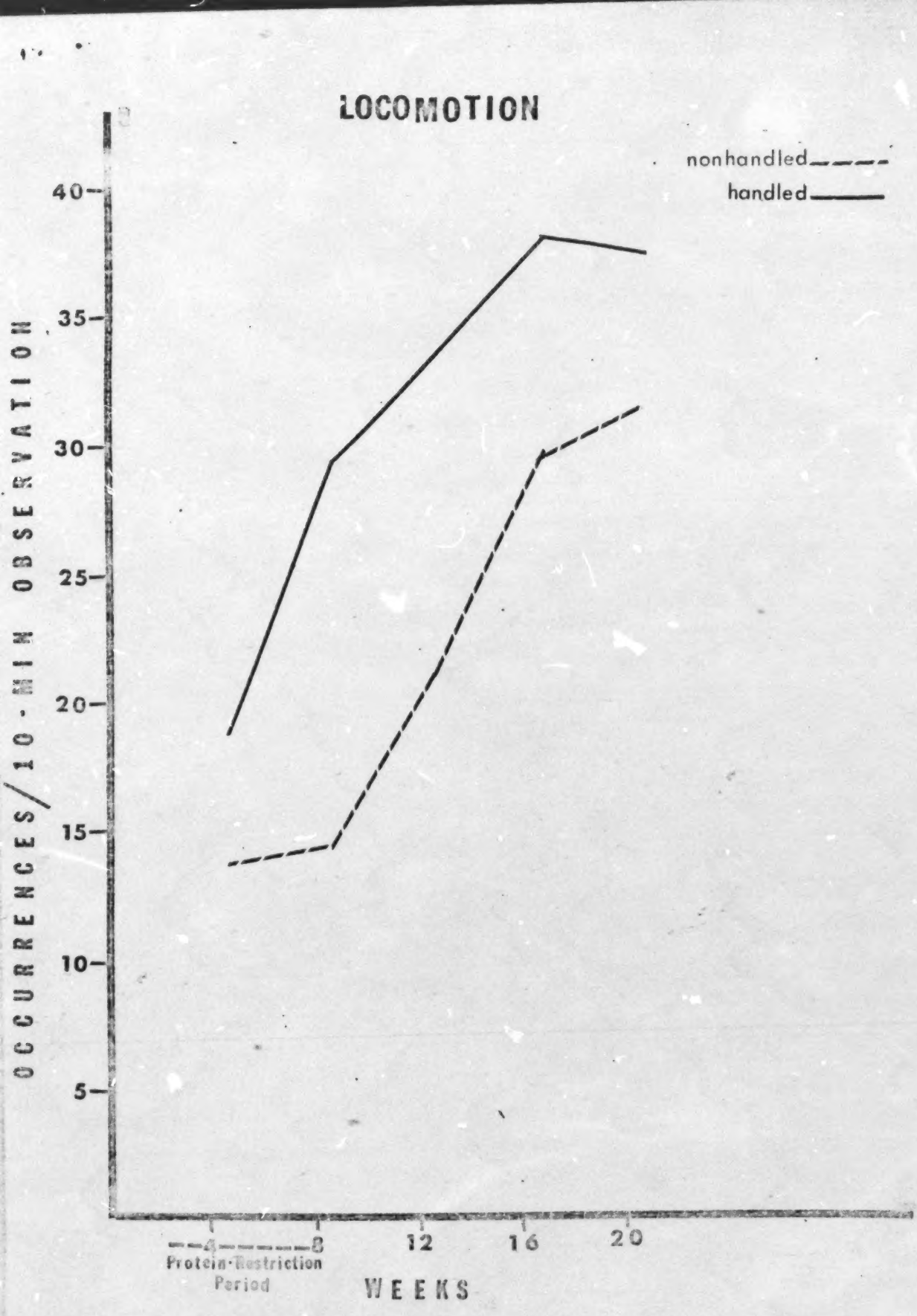

GROWTH OF CONTROL AND DEFICIENT FEMALE SQUIRREL MONKEYS
protein deficient
control
shaded area = standard ± 2 S.D. (n = 12)
death of one animal
BODY WEIGHT (GRAMS)
700
600
500
400
300
200
100
0
protein restriction period
5
10
15
20
25
30
35
40
45
50
AGE (WEEKS)


Plasma Protein & Albumin Concentration in Control & Protein Deficient Monkeys
control
protein deficient
⊥ = s.e.m.
* = p < .05
Plasma Protein (g/dl)
Plasma albumin (g/dl)
8
7
6
5
4
3
2
0
0
protein restriction period
5
10
15
20
25
30
35
40
45
50
AGE (WEEKS)

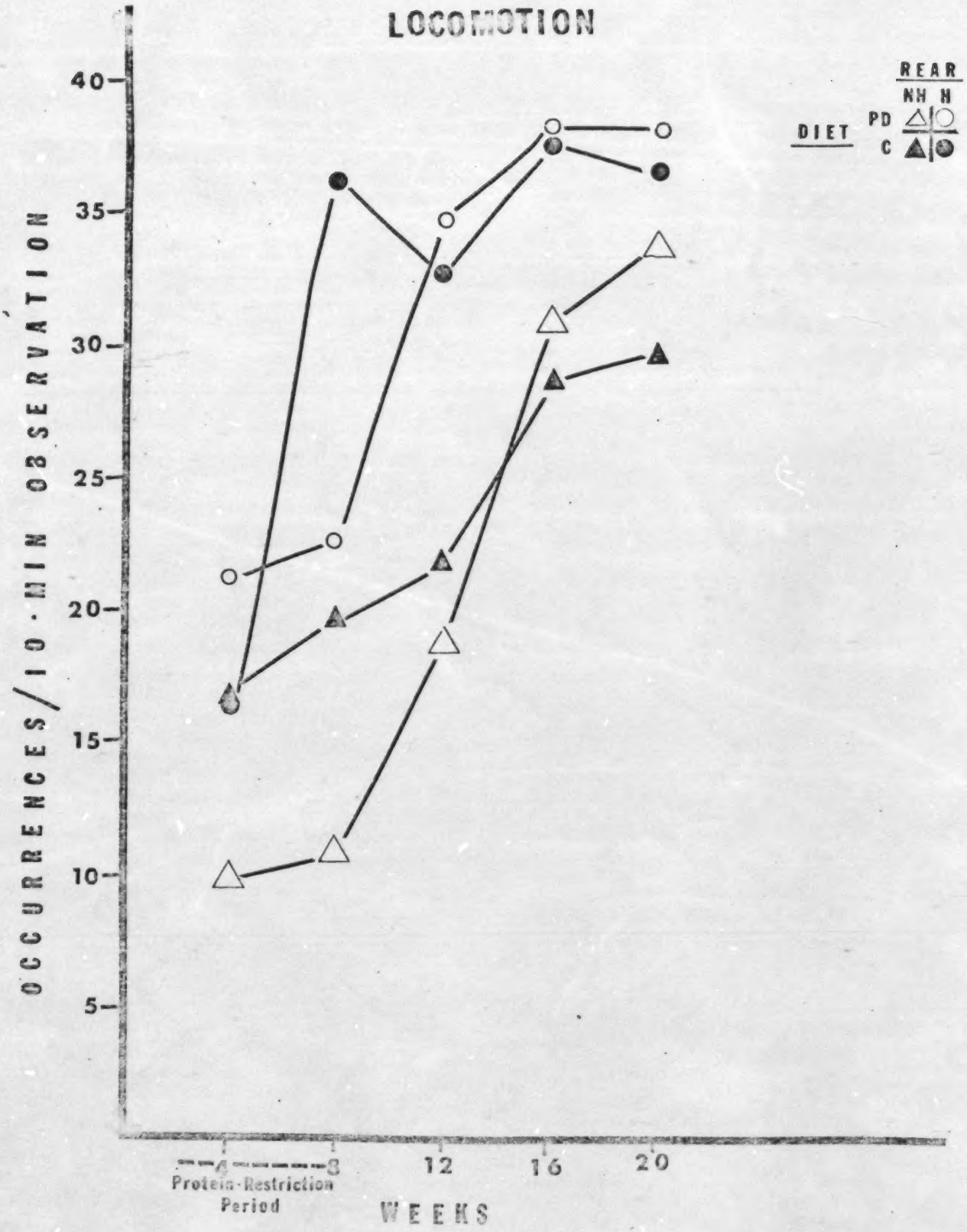

HEMOGLOBIN (G/DL)
15
14
13
12
11
10
CONTROL
PROTEIN DEFICIENT
S.E.M.
P< .05

LOCOMOTION


protein deficient
control
OCCURRENCES/10-MIN OBSERVATION
40
35
30
25
20
15
10
5
Protein-Restriction Period
3
12
16
20
WEEKS
DIET


LOCOMOTION
nonhandled
handled
40
35
30
25
20
15
10
5
OCCURRENCES/10-MIN OBSERVATION
4
8
12
16
20
Protein-Restriction Period
WEEKS

REARING



DIET X REARING 00011